

Preliminary Results from Simultaneous Cryo Test of Three 0.5 m Mirrors

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Description of Test



- Had three 0.5 m diameter, 20 m radius lightweight mirrors from various sources:
 - 8 kg/m² C/SiC from IABG (tested once previously)
 - VHP Joined-Beryllium from Brush-Wellman/Goodrich
 - 22 kg/m² SiC from Xinetics
- Developed test stand to hold all three mirrors to enable simultaneous cryo testing.
- Particularly interested in:
 - Repeatability of C/SiC cryo deformation (previously tested)
 - Print-thru of Joined-Be
 - Performance of SiC versus C/SiC

3-Mirror Test Set-Up

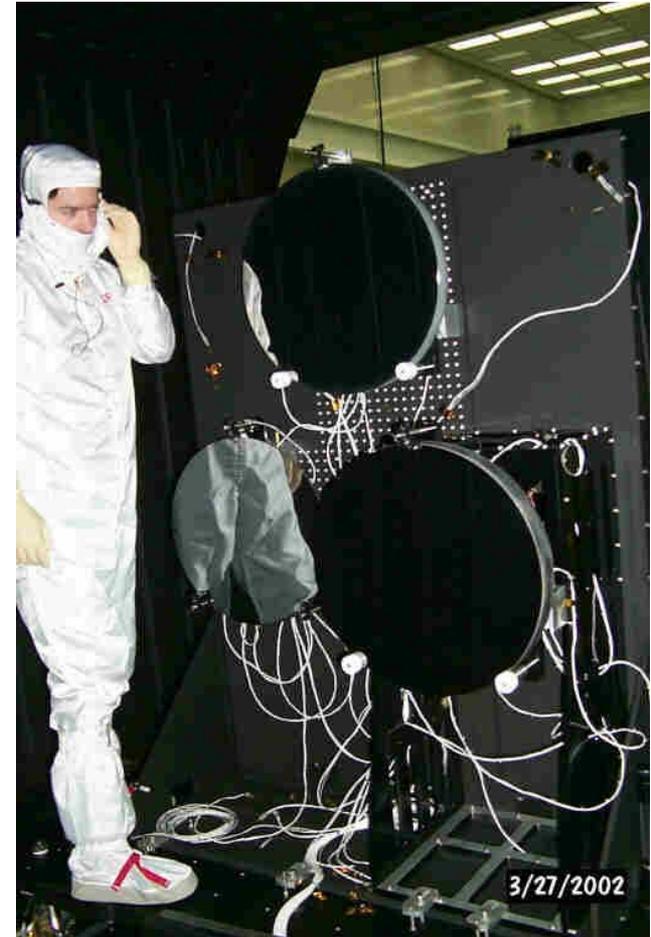


JBe

C/SiC



SiC



PhaseCam Pallet



- PhaseCam interferometer with F/33 diverger.
- Reference sphere for subtraction of instrument errors.
- Intellwave software.
- Leica Disto Pro distance meter for RoC.
- Pallet atop Hexapod 6-DOF platform (pivot point set at common mirror CoC).

Definitions

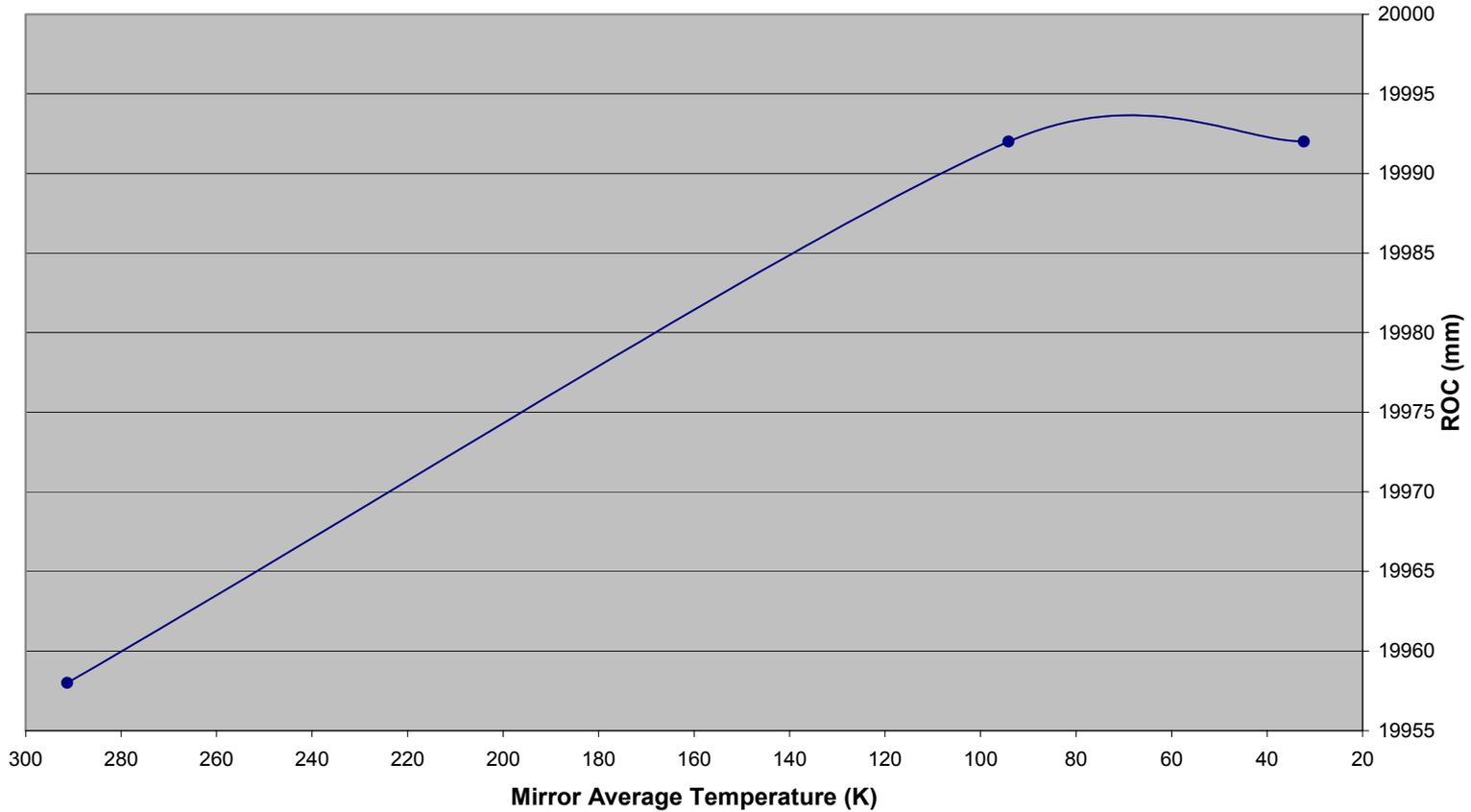


- Total Result - surface error map with piston, tilt, & focus removed.
- Zernike Fit - fit of first 36 terms.
- Residual - difference of Total & Zernike Fit.

C/SiC RoC vs Temperature



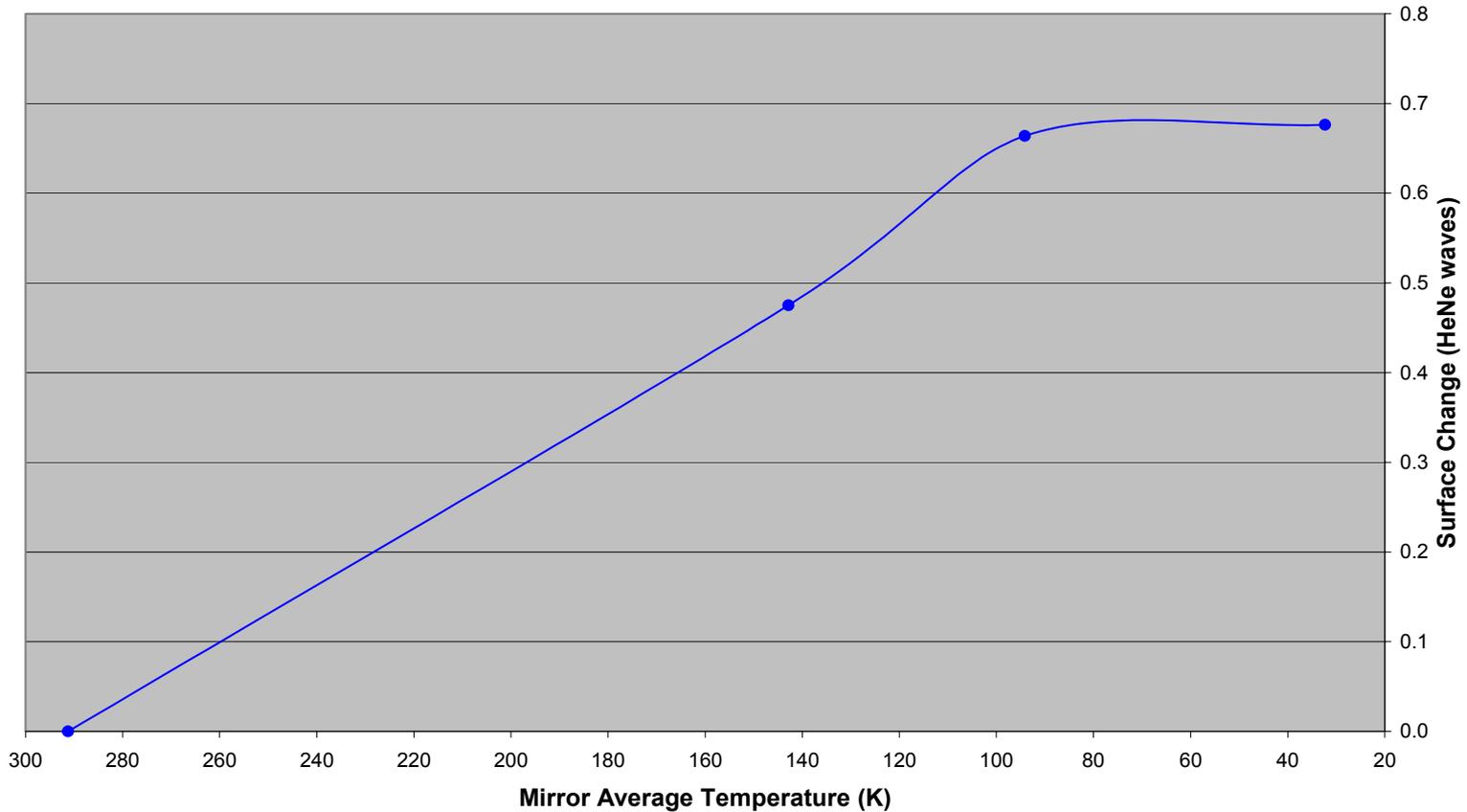
CSiC - ROC



C/SiC RMS Cryo Deformation vs Temperature



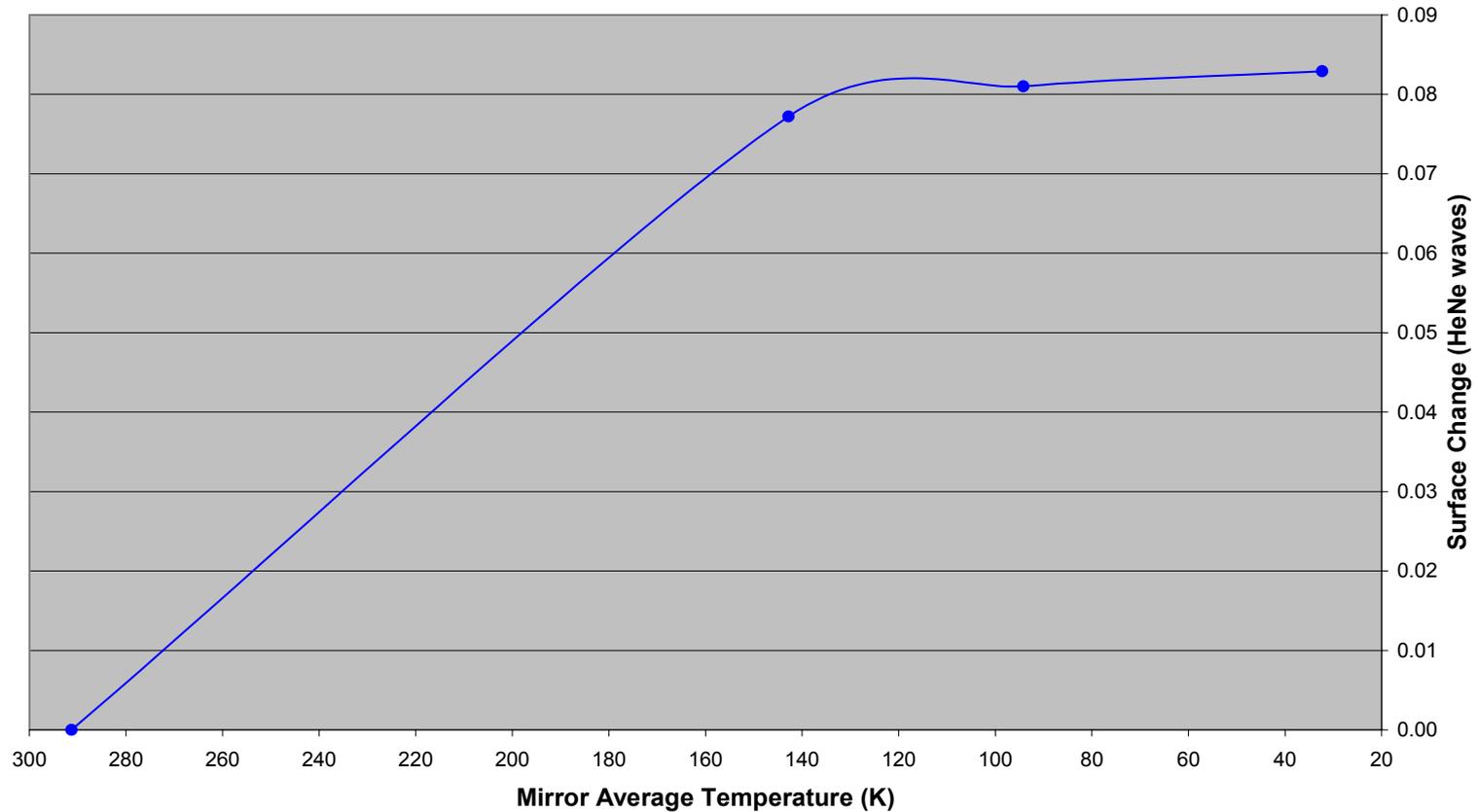
CSiC - RMS Surface Change from 291 K



C/SiC RMS Residual Cryo Deformation vs Temperature



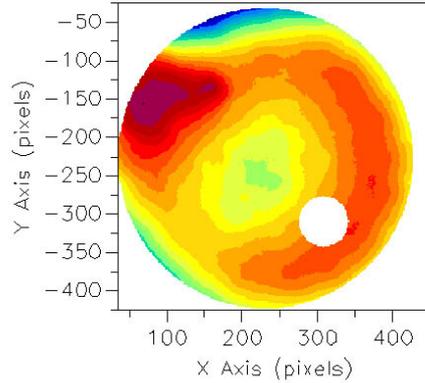
CSiC - RMS Residual Surface Change from 291 K



C/SiC Ambient Figure

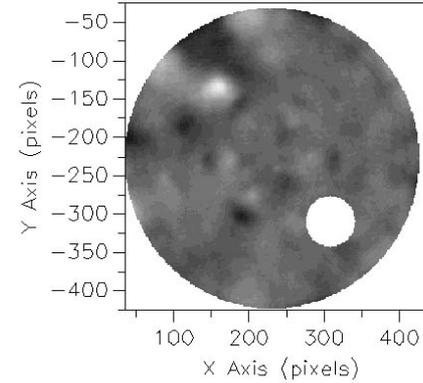


IntelliWave: Surface Map [4AM.TMD]
Date Acq: 04/02/02, 15:22:37
FILE: CSIC_VAC_291A_REF_MSK3.ESD



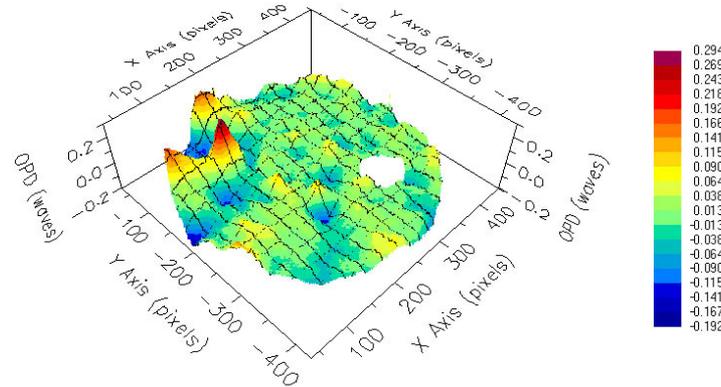
Range (PV) = 2.1818 waves, RMS = 0.3031 waves, Strehl = 0.0266
Analysis Aper: Pos[232, 228] Size[394, 394]

IntelliWave: Surface Map [4AM.TMD]
Date Acq: 04/02/02, 15:22:37
FILE: CSIC_VAC_291A_REF_MSK3.ESD



Range (PV) = 0.4865 waves, RMS = 0.0443 waves, Strehl = 0.9255
Analysis Aper: Pos[232, 228] Size[394, 394]

IntelliWave: Surface Map [4AM.TMD]
Date Acq: 04/02/02, 15:22:37
FILE: CSIC_VAC_291A_REF_MSK3.ESD

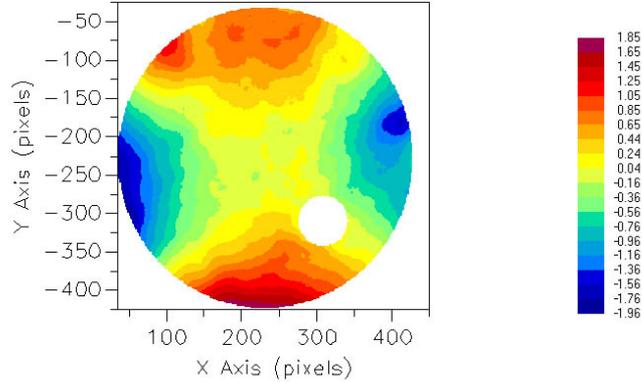


Range (PV) = 0.4865 waves, RMS = 0.0443 waves, Strehl = 0.9255
Analysis Aper: Pos[232, 228] Size[394, 394]

C/SiC Cryo Deformation

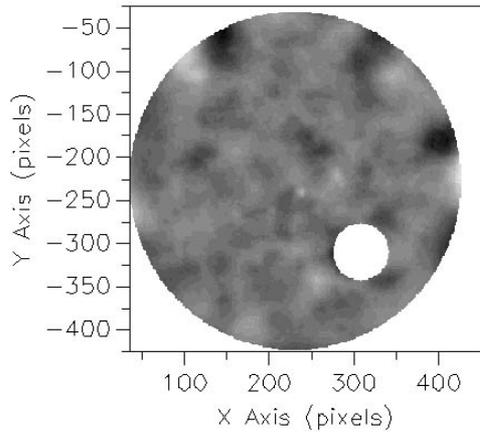


IntelliWave: Surface Map [4A.M.TMD]
Date: Acq: 04/02/02, 15:22:37
FILE: CSiC_VAC_33-291A_MSK3.ESD



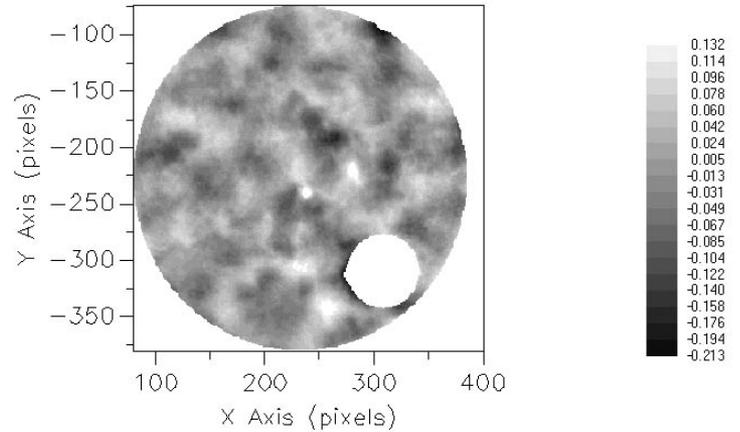
Range (PV) = 3.8104 waves, RMS = 0.6764 waves, Strehl = 0.0000
Analysis Aper: Pos[232, 228] Size[394, 394]

IntelliWave: Surface Map [4A.M.TMD]
Date: Acq: 04/02/02, 15:22:37
FILE: CSiC_VAC_33-291A_MSK3.ESD



Range (PV) = 0.8911 waves, RMS = 0.0829 waves, Strehl = 0.7623
Analysis Aper: Pos[232, 228] Size[394, 394]

IntelliWave: Surface Map [4A.M.TMD]
Date: Acq: 04/02/02, 15:22:37
FILE: CSiC_VAC_33-291A_MSK4_CLIP.ESD



Range (PV) = 0.3450 waves, RMS = 0.0484 waves, Strehl = 0.9118
Analysis Aper: Pos[233, 228] Size[307, 308]

C/SiC Summary

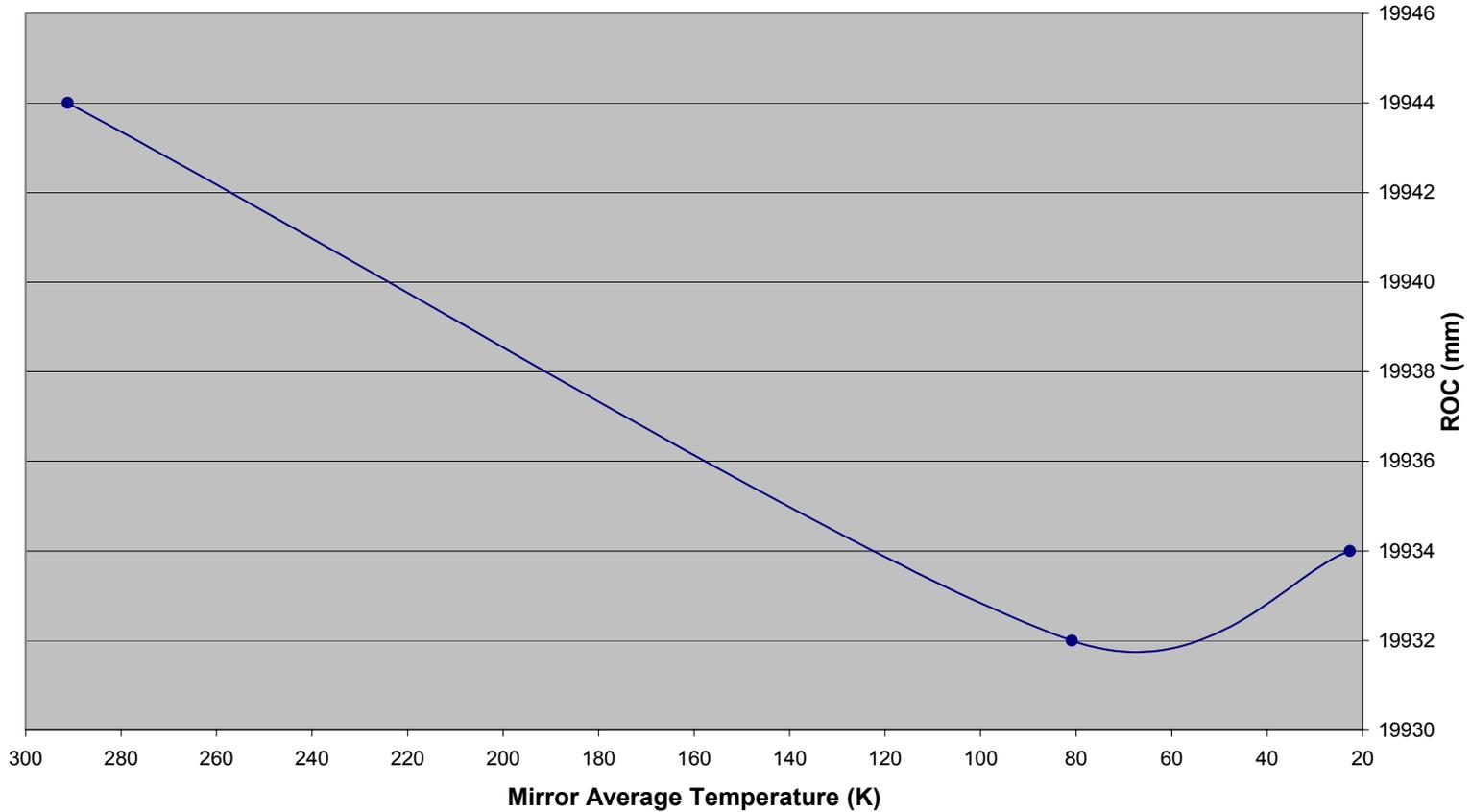


- RoC increase of 35 mm is unexpected.
- Changes tend to level off between 100 & 150 K, corresponding to level off of SiC CTE.
- Total surface figure change of about 0.7 waves (443 nm) RMS. Mostly astigmatism due to felt lay-up during fabrication. Saw 81 nm RMS for SBMD.
- High-frequency surface figure change of about 0.08 waves (51 nm) RMS, or 0.05 waves (32 nm) RMS without edge effects. Saw 16 nm RMS for SBMD. Can see some print-thru of ribs, but also a more random-looking component.
- Difference of 0.016 waves (10 nm) RMS between pre & post-cryo ambient figure - astigmatism. Need to check for measurement errors before concluding that a permanent change occurred.
- RoC & RMS figure changes same as in first test. PV figure changes about twice first test (may be due to different masking, shape looks same).

JBe RoC vs Temperature



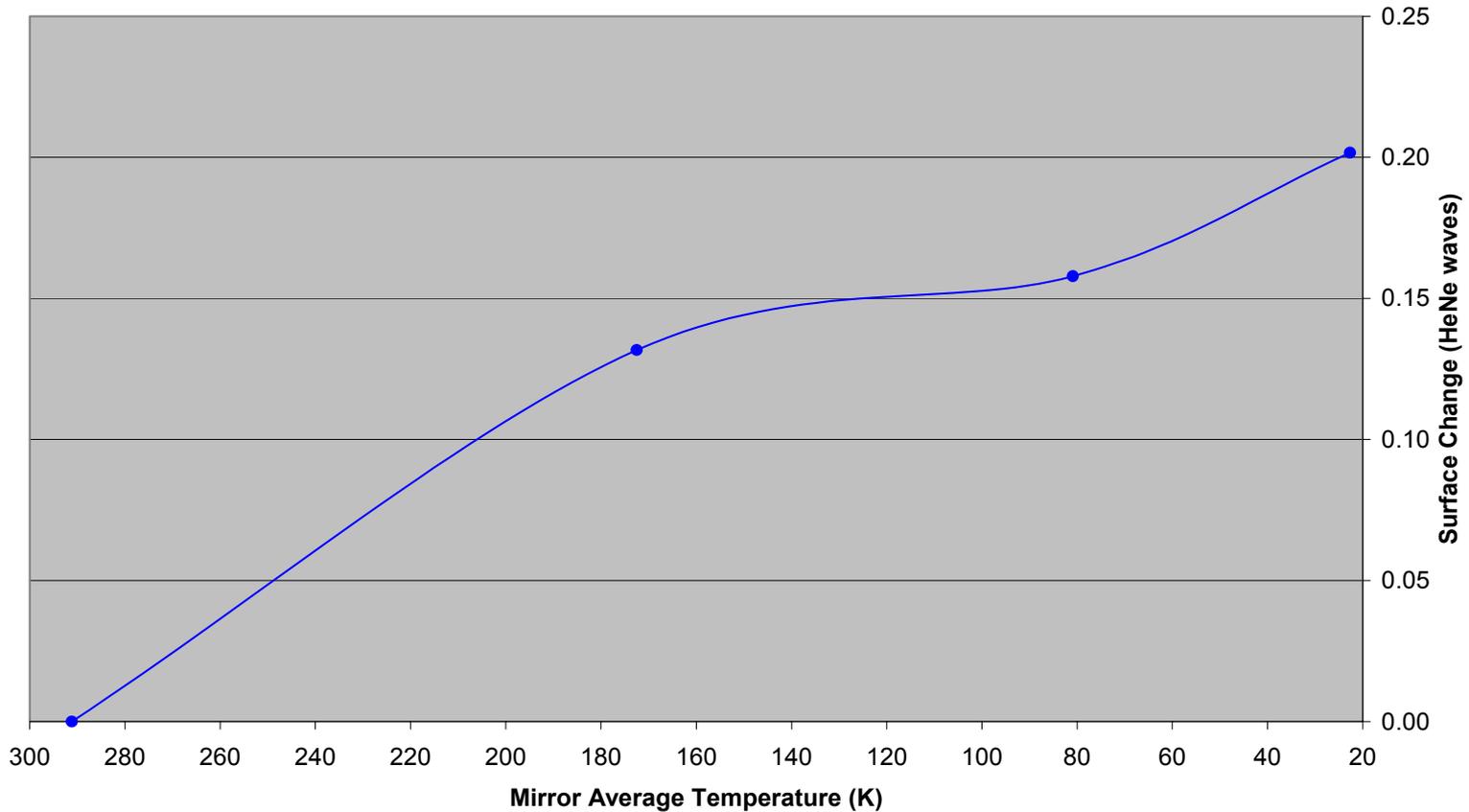
JBe - ROC



JBe RMS Cryo Deformation vs Temperature



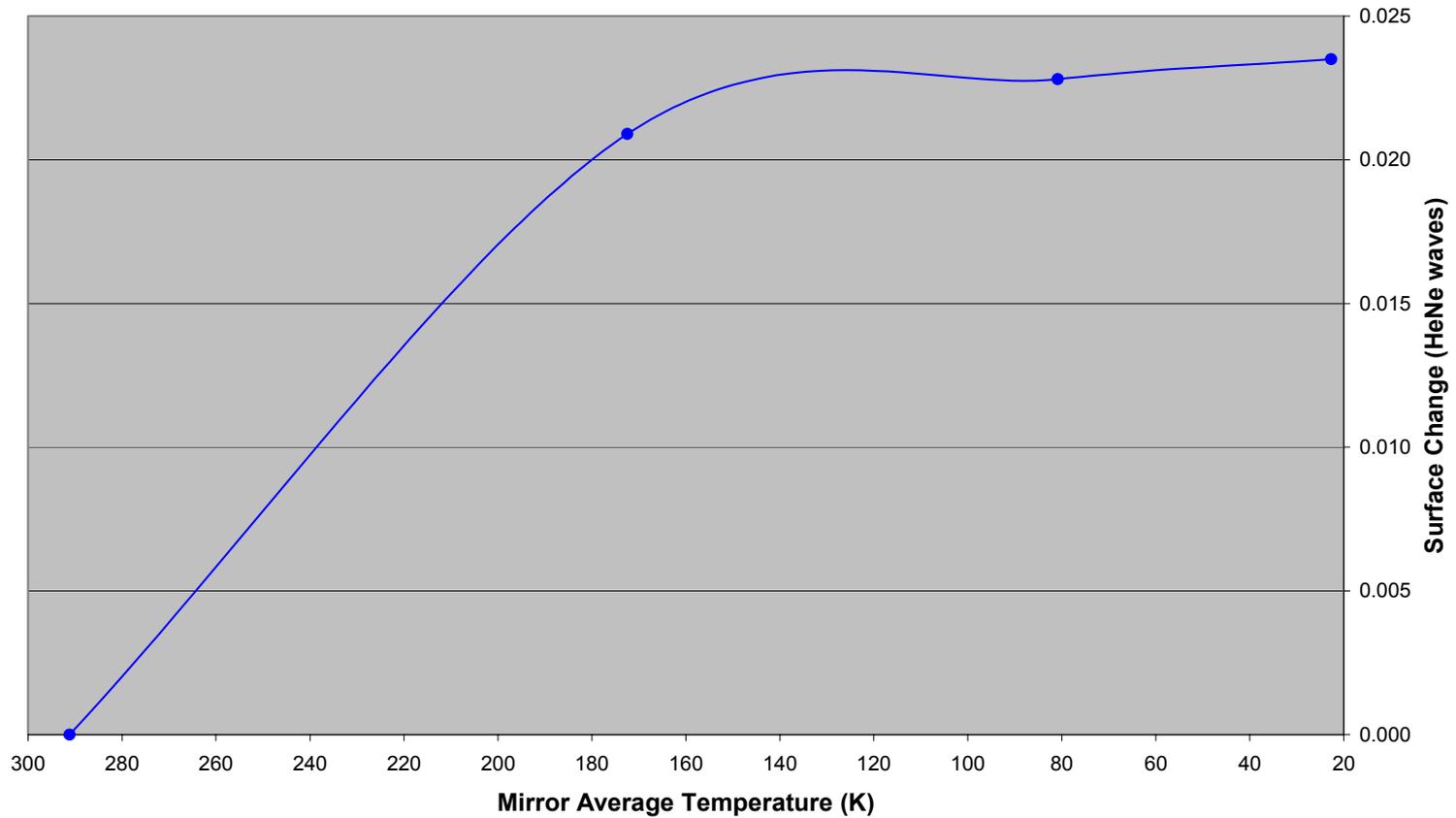
JBe - RMS Surface Change from 291 K



JBe RMS Residual Cryo Deformation vs Temperature



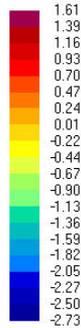
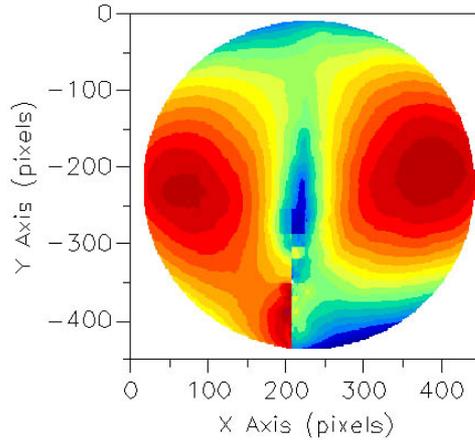
JBe - RMS Residual Surface Change from 291 K



JBe Ambient Figure

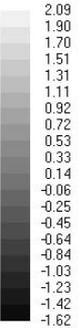
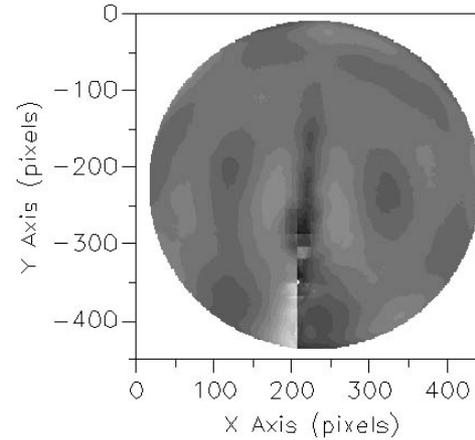


IntelliWave: Surface Map [4AM,TMD]
Date: Acq.: 04/02/02, 15:53:10
FILE: JBE_VAC_291A_REF_MSK.ESD



Range (PV) = 4.3472 waves, RMS = 0.8869 waves, Strehl = 0.0000
Analysis Aper: Pos[230, 224] Size[429, 430]

IntelliWave: Surface Map [4AM,TMD]
Date: Acq.: 04/02/02, 15:53:10
FILE: JBE_VAC_291A_REF_MSK.ESD

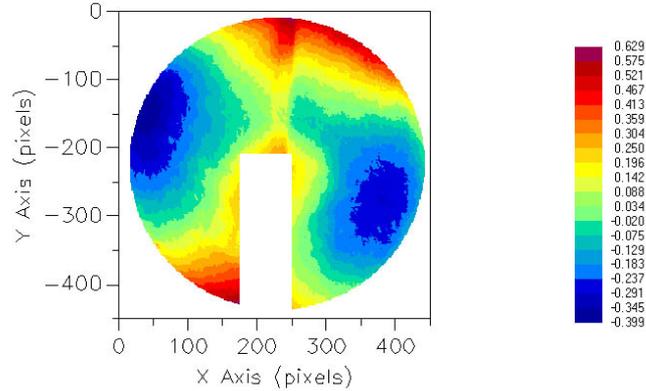


Range (PV) = 3.7056 waves, RMS = 0.2523 waves, Strehl = 0.0811
Analysis Aper: Pos[230, 224] Size[429, 430]

JBe Cryo Deformation

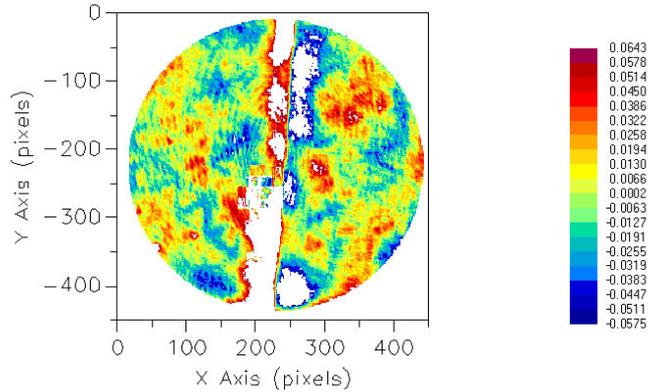


IntelliWave: Surface Map [4AM.TMD]
Date Acq: 04/02/02, 15:53:10
FILE: JBE_VAC_23-291A_MSK2.ESD



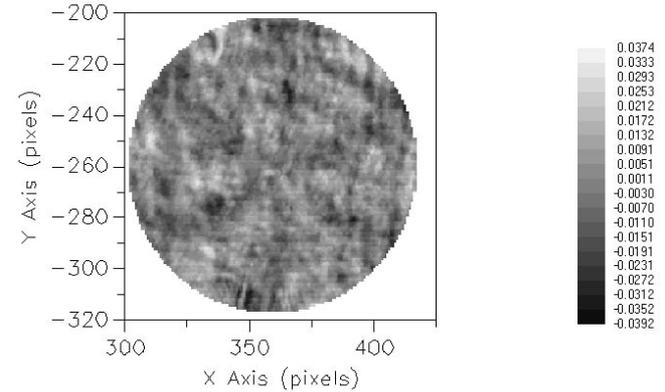
Range (PV) = 1.0287 waves, RMS = 0.2016 waves, Strehl = 0.2010
Analysis Aper: Pos[230, 224] Size[429, 430]

IntelliWave: Surface Map [4AM.TMD]
Date Acq: 04/02/02, 15:53:10
FILE: JBE_VAC_23-291A_RES_CLIP.ESD



Range (PV) = 0.1218 waves, RMS = 0.0235 waves, Strehl = 0.9785
Analysis Aper: Pos[230, 224] Size[429, 430]

IntelliWave: Surface Map [4AM.TMD]
Date Acq: 04/02/02, 15:53:10
FILE: JBE_VAC_23-291A_MSK3R.ESD



Range (PV) = 0.0766 waves, RMS = 0.0104 waves, Strehl = 0.9957
Analysis Aper: Pos[360, 260] Size[118, 118]

JBe Summary

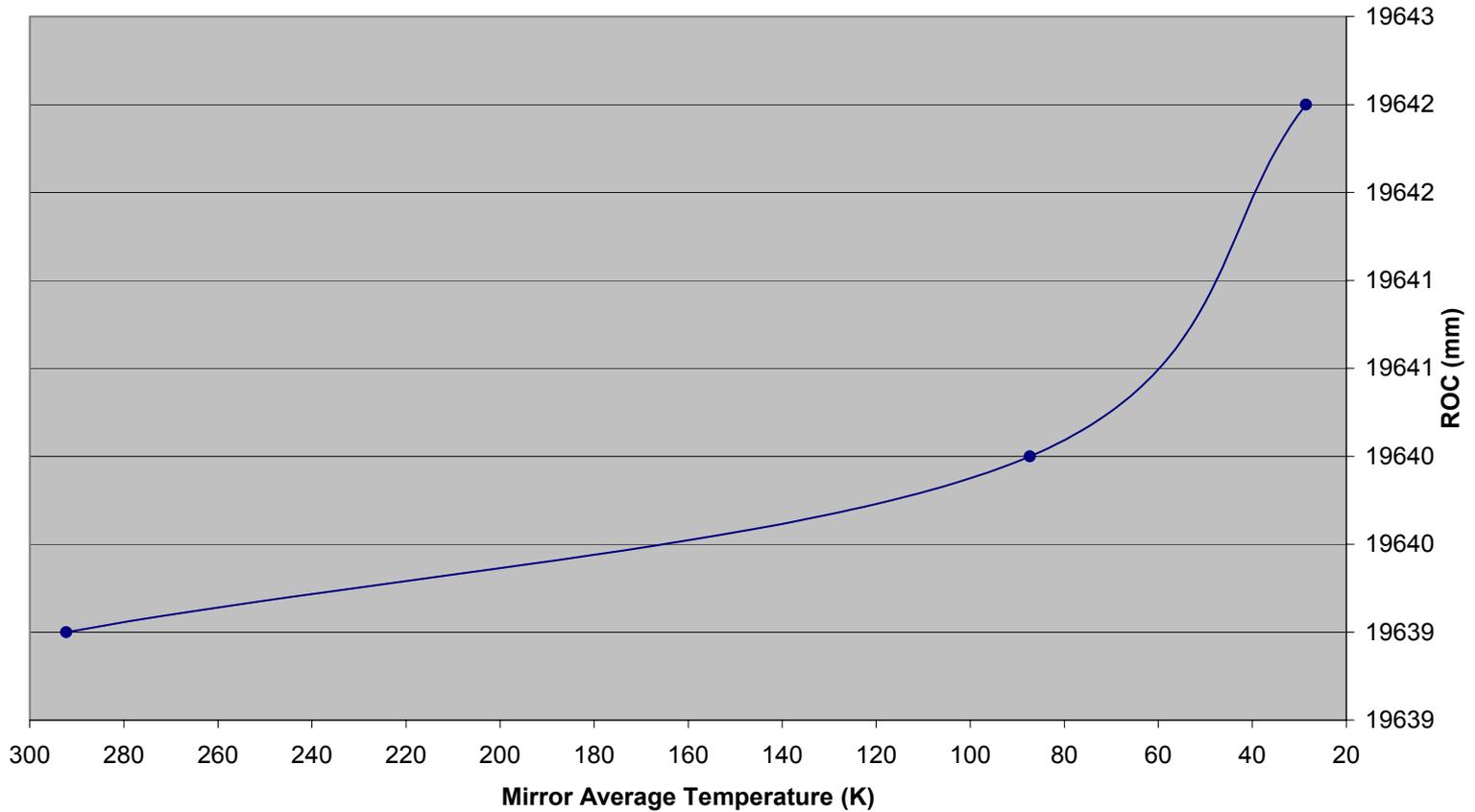


- RoC decrease of 10 mm is less than the expected 26 mm.
- Changes tend to level off around 140 K, corresponding to level off of Be CTE.
- Total surface figure change of about 0.2 waves (127 nm) RMS. Mostly astigmatism, but may actually be “power” changes of left & right halves. Some change around intact portion of joining seam. Saw 81 nm RMS for SBMD.
- High-frequency surface figure change of about 0.02 waves (13 nm) RMS, or 0.01 waves (6 nm) RMS per “pocket”. Saw 16 nm RMS for SBMD. Can see print-thru of ribs, but also a more random-looking component. No real difference between thin & thick rib print-thru.
- Difference of 0.018 waves (11 nm) RMS between pre & post-cryo ambient figure - astigmatism. Need to check for measurement errors before concluding that a permanent change occurred.

SiC RoC vs Temperature



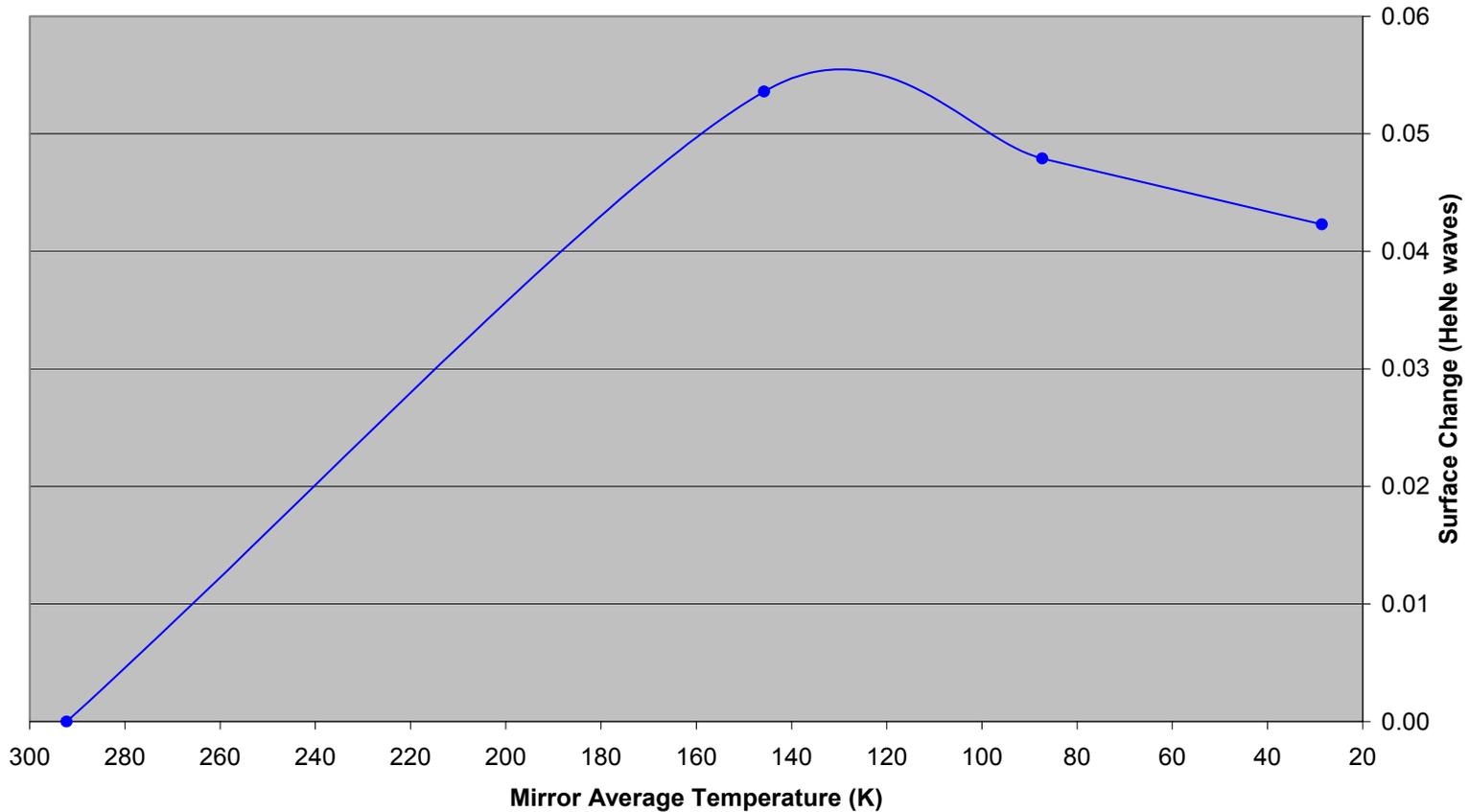
SiC - ROC



SiC RMS Cryo Deformation vs Temperature



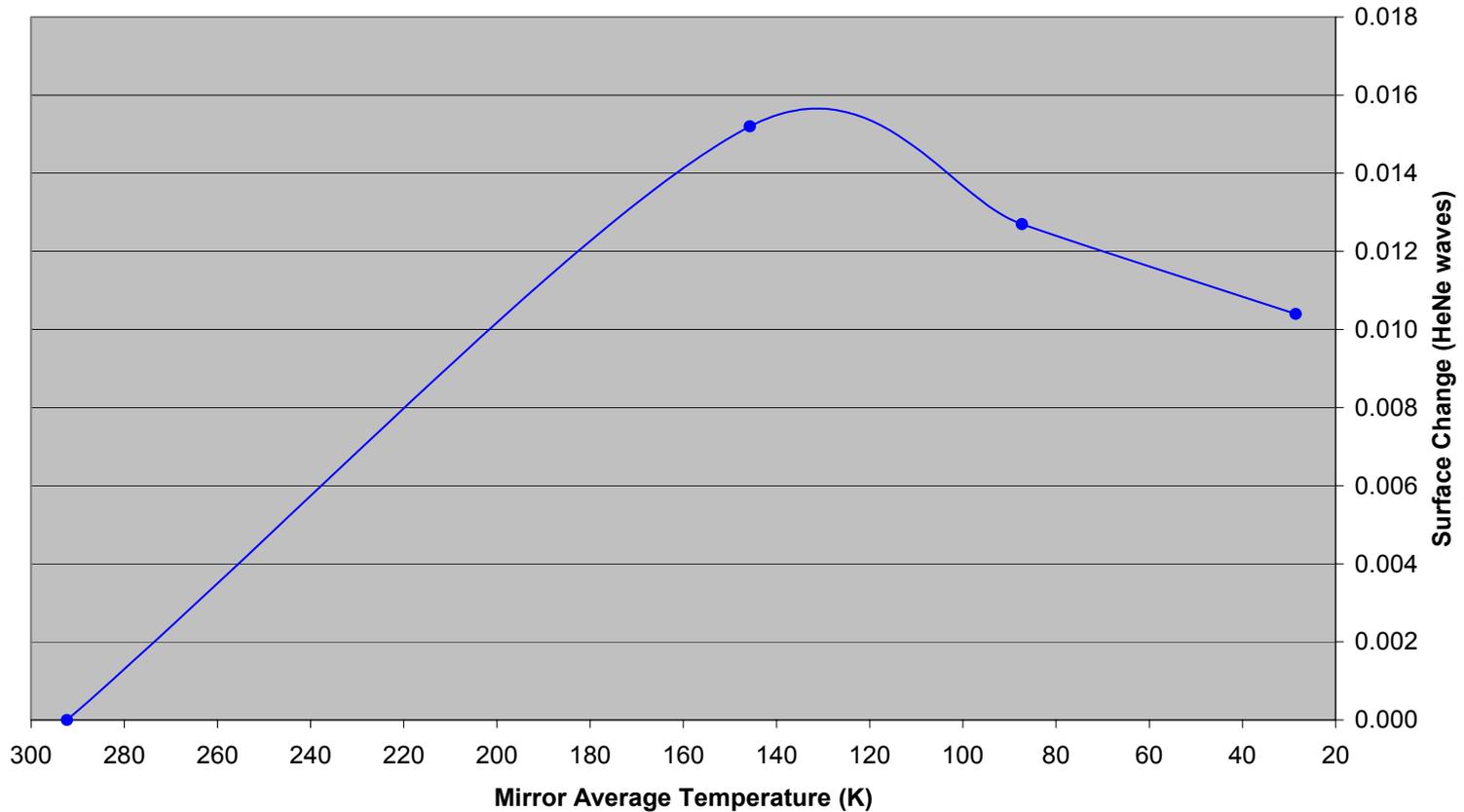
SiC - RMS Surface Change from 293 K



SiC RMS Residual Cryo Deformation vs Temperature



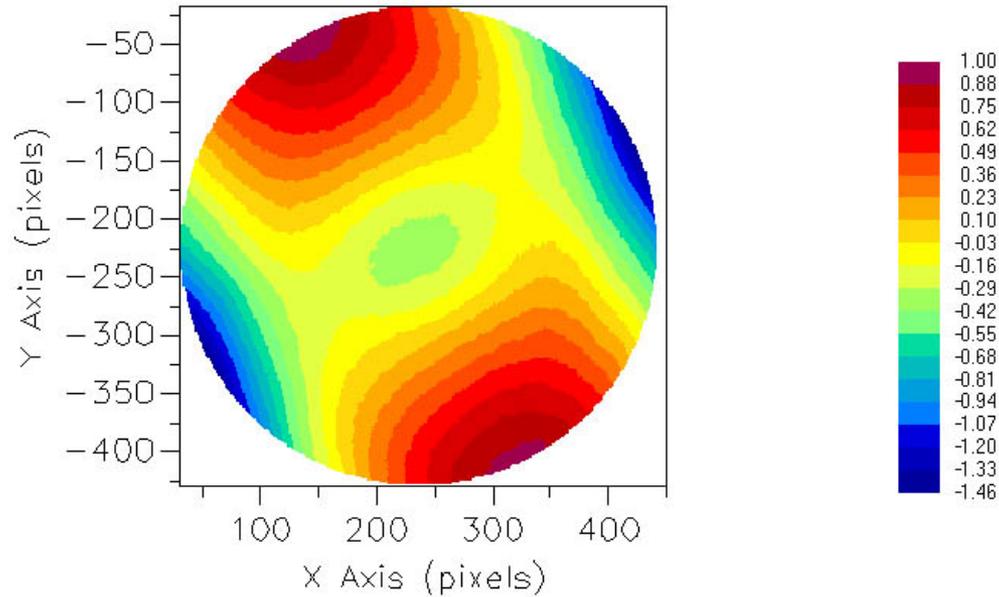
SiC - RMS Residual Surface Change from 293 K



SiC Ambient Figure



IntelliWave: Surface Map [4A.M.TMD]
Date: Acq.: 04/02/02, 14:42:30
FILE: SIC_VAC_293A_REF_MSK.ESD

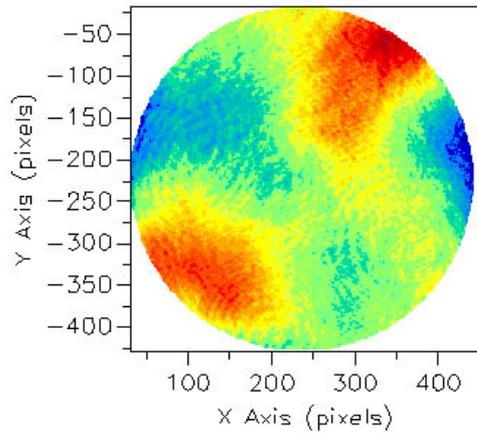


Range (PV) = 2.4627 waves, RMS = 0.4684 waves, Strehl = 0.0002
Analysis Aper: Pos[237, 224] Size[413, 414]

SiC Cryo Deformation

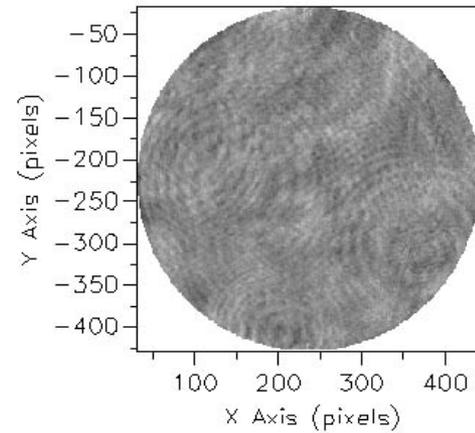


InteWave: Surface Map [4A.M.TMD]
Date: Acq.: 04/02/02, 14:42:30
FILE: SIC_VAC_30-293.AESD



Range (PV)= 0.2751 waves, RMS = 0.0423 waves, Strehl= 0.9319
Analysis Aper: Pos [237, 224] Size [413, 414]

InteWave: Surface Map [4A.M.TMD]
Date: Acq.: 04/02/02, 14:42:30
FILE: SIC_VAC_30-293.AESD



Range (PV)= 0.1404 waves, RMS = 0.0104 waves, Strehl= 0.9957
Analysis Aper: Pos [237, 224] Size [413, 414]

SiC Summary



- Change in RoC of +3 mm is within +/-6 mm error bar of measurement - would expect -6 mm change from SiC CTE.
- Changes tend to level off around 160 K, corresponding to level off of SiC CTE.
- Total surface figure change of only about 0.04 waves (25 nm) RMS. Combination of trefoil & astigmatism. Saw 81 nm RMS for SBMD.
- High-frequency surface figure change of only about 0.01 waves (6 nm) RMS, which is probably near noise limit of difference plot. Saw 16 nm RMS for SBMD. Can not see any print-thru.
- Difference of 0.014 waves (9 nm) RMS between pre & post-cryo ambient figure - trefoil. Need to check for measurement errors before concluding that a permanent change occurred.

Conclusions



- Successfully cryo-tested three 0.5 m diameter, 20 m radius lightweight mirrors simultaneously, saving cost & schedule.
- C/SiC results very repeatable from first test. Observed unexpected RoC increase. Observed rib print-thru, but along with other high-frequency error.
- Did observe some rib print-thru for JBe, but much less than for SBMD (however, not same areal density). Observed some deformation around seam, but not sure of crack influence in this area.
- SiC mirror performed very well, but not same areal density as C/SiC (22 vs 8 kg/m²).

Contacts



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